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Monterey, California

THESIS

F993

SLOWDOWN IN SOVIET DEFENSE EXPENDITURES:
VARIATIONS OF A SUGGESTED MODEL

by

Michael Fuzy III

June 1989

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T244076

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No 0704-0188

1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION AVAILABILITY OF REPORT Approved for public release; distribution is unlimited
2b DECLASSIFICATION / DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S)	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION Naval Postgraduate School; 6b OFFICE SYMBOL (If applicable) Code 54	7a NAME OF MONITORING ORGANIZATION Naval Postgraduate School
6c ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000	7b ADDRESS (City State, and ZIP Code) Monterey, California 93943-5000
8a NAME OF FUNDING / SPONSORING ORGANIZATION; 8b OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c ADDRESS (City, State, and ZIP Code)	10 SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO; PROJECT NO; TASK NO; WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification)

SLOWDOWN IN SOVIET DEFENSE EXPENDITURES: VARIATIONS OF A SUGGESTED MODEL

12 PERSONAL AUTHOR(S)

Fuzy, Michael III

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Master's Thesis	FROM ____ TO ____	1989, June	62

16 SUPPLEMENTARY NOTATION

The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Regression; Likelihood Ratio; Chi-squared; Chow test

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

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20 DISTRIBUTION AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION Unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL Prof. Rudolfo Gonzales	22b TELEPHONE (Include Area Code) (916) 756-0452; 22c OFFICE SYMBOL Code 54Gn

DD Form 1473, JUN 86 Previous editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED

S/N 0102-LF-014-6603

#19 - ABSTRACT - (CONTINUED)

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Slowdown in Soviet Defense Expenditures: Variations of a Suggested Model

by

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
June 1989

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ABSTRACT

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I. INTRODUCTION

In 1974 Economist Paul R. Gregory presented a simple model which sought to explain real Soviet defense expenditures in terms of Soviet economic growth and real U.S. defense spending. The model showed Soviet defense spending to be a statistically significant and positive function of both Soviet GNP and U.S. defense expenditure. Specifically a 1% increase in U.S. defense spending brought about roughly a 0.6% increase in Soviet defense spending and a 1% increase in Soviet GNP brought about approximately a 0.7% increase in Soviet defense expenditures [Ref. 1].

Information on Soviet defense spending is hard to come by. It is a closely guarded state secret. Only one defense figure is published in the state budget each year and it is uninformative because its scope is not defined and its size appears to be manipulated to suit Soviet political purposes. Economists such as Gregory tried to determine Soviet defense expenditures through the use of models that use more accurate variables. The CIA on the other hand uses a complex costing methodology to estimate Soviet defense expenditures. Data collected by the Central Intelligence Agency (CIA) indicate that the growth of Soviet defense expenditures has decreased since 1977.

In a study using the Gregory model as a basis, Josef C. Brada and Ronald L. Graves attempted to test alternative hypotheses regarding the causes of the slowdown in Soviet defense expenditures that occurred in the mid-1970s [Ref. 2]. Their models used high and low Soviet defense expenditure estimates to determine parameter estimates for their equations. The parameter estimates using the high Soviet defense expenditure estimates resulted in different conclusions from the parameter estimates using the low expenditure estimates.

The primary investigative effort of this thesis was to examine, using statistical analysis, the Brada and Graves study and to determine the effect on the parameter estimates of the determinants of Soviet defense expenditures if the mean estimated values of Soviet defense expenditures for the period 1960-1984 are used instead of high and low estimates.

The second chapter of this thesis explained the variables used in the four different models that were developed by Brada and Graves for the purpose of forecasting Soviet defense expenditures.

The essence of the thesis is contained in the chapters on the description of the models and on data presentation. They give a precise step by step development of the hypothesis testing through the use of regression analysis, likelihood ratios, chi-square procedures, and the Chow test.

Also, a model was developed with a different variable to determine if the explanatory power could be increased. The same methods of hypothesis testing as the previous models were used with the addition of testing in lagged form.

The concluding chapters showed, through the use of the various models and statistical tests, that the change in Soviet defense expenditures in the mid-1970s was not solely a natural response to exogenous variables that constrain Soviet decisions regarding the level of defense expenditure, but a response both to exogenous variables and to the Soviet leaders' perceptions of defense needs.

II. BACKGROUND

Economist Paul R. Gregory believes that real Soviet GNP and real U.S. defense outlays are the two primary factors in explaining Soviet defense expenditures. His rationale is that in the Soviet Union, as in other economies, real economic growth generates real growth in revenues which the state must then allocate among a myriad of programs. With a constant allocation rate, defense expenditures would tend to remain a fixed proportion of Soviet GNP and would grow proportionately with the growth of GNP. Any variation in Soviet GNP would explain variations in the defense expenditure. However, allocated proportions for Soviet defense have varied substantially over time in the Soviet Union. This requires consideration of a second factor that causes variation in the ratio of real Soviet defense expenditures to real Soviet GNP. This second factor is real U.S. defense outlays. Gregory assumes that increases in the Soviet defense budget are based upon the Soviet leadership's perception of real military needs. The idea here is that because the United States has been the Soviet Union's major competitor in the military sphere, the Soviet leaders' perception of their military needs must have been fashioned to a large extent by changes in U.S. military expenditures.

Since the Gregory model was developed, data on Soviet defense expenditures compiled by the CIA indicate that the rate of growth of Soviet defense expenditures has decreased since 1977. The CIA and a number of other analysts believe that the slowdown is caused primarily by two objective factors that constrain the ability of the Soviet Union to maintain a higher rate of growth of defense expenditures. According to the CIA, the first factor is the decline of aggregate Soviet economic growth. For future Soviet economic growth and for continuation of specific programs such as energy conservation and production, the modernization of industry, and the development of Siberia and its natural resources, capital formation is critical. This is a price effect because investment needs in other industries increased the cost of defense. This, combined with an income effect, where a slowdown in the growth of GNP caused a slowdown in the growth of Soviet defense expenditures, increases the burden of the defense expenditures greatly. Therefore, the decline in the expansion of the share of national income devoted to defense implies that the slowdown in aggregate economic growth has constrained the growth of national defense expenditures. The second factor causing the slower growth of Soviet military spending, according to the CIA, is that the technological and physical bottlenecks that plague the civilian economy have also spilled over into the defense sector. Because of technological difficulties in making new weapons systems function properly and also because of difficulties in organizing the production of new weapons, the Soviets have had to stretch out the procurement of such new systems thereby reducing defense expenditures below what the Soviets would wish to spend even with a slowing economy.

To summarize up to this point, Gregory believes that two variables--Soviet GNP and U.S. defense expenditures--affect Soviet defense expenditures. The CIA believes that two of the variables that have affected the Soviet defense expenditure are Soviet GNP and factor productivity growth.

An alternate view is that Soviet defense expenditures are affected by the three variables noted above--Soviet GNP, factor productivity growth, and U.S. defense expenditures--plus a fourth variable which is the slowdown in the Soviet acquisition of additional strategic weapons. This slowdown could be caused by one of two factors. The first is that the Soviet leaders' may have come to believe that they had reached their objective of strategic parity with the United States. The second is that Soviet military doctrine may have switched from an emphasis on winning a nuclear exchange to a policy that regarded nuclear exchanges as unwinnable and thus downplayed the emphasis on strategic parity and placed greater emphasis on conventional warfare.

In summary, four factors are believed to determine the amount of Soviet defense expenditures. They are Soviet GNP, real United States defense expenditures, growth of Soviet factor productivity in industry (which correlates to the technological and production bottlenecks), and the ratio of deliverable Soviet warheads to deliverable U.S. warheads (which correlates to the slowdown in the Soviet acquisition of additional strategic weapons). The first three variables are basically exogenous and not controlled by Soviet leaders. The fourth variable is determined more by the Soviet leaders and their view of military needs.

With these variables, statistical models can be used to determine whether the slowdown in Soviet defense expenditures represents a strictly natural response to changes in the exogenous variables that determined the level of defense expenditures, or whether Soviet decisionmakers in the mid-1970s changed their views regarding the level of defense expenditures.

Which of the two explanations considered in the above paragraph is right should heavily influence the United States' defense policy. If Soviet GNP and U.S. defense expenditures are the only influential determinants of Soviet defense expenditures, then an increase in U.S. defense spending could cause two possible outcomes. First, the Soviet Union would not be able to follow suit and would find itself at a military disadvantage. Second, the Soviet Union could also increase its defense expenditures at the cost of neglecting its economy and therefore causing economic stagnation. This in the long run would make the Soviet Union even more incapable of meeting its military needs.

In the case of the second interpretation of the slowdown in Soviet defense expenditures (that the Soviet leadership's changed perceptions of defense needs are dependent on more variables than just U.S. defense expenditures and Soviet GNP), an increase of defense expenditures by the United States would have undesirable consequences for the following reasons:

1. If Soviet defense expenditures are only partly limited by objective factors and partially governed by self-restraint, it would be possible for the Soviet Union to increase its defense expenditures without neglecting its economy and causing economic stagnation.

2. The Soviet Union would be less likely to practice as much self-restraint as it has in the past if the United States increased its defense expenditure growth rate.

3. The Soviet Union could view a United States increase in defense expenditure as a means to gain military superiority, thereby making relations based on mutual trust and restraint in the future difficult to establish.

III. METHODOLOGY

Josef C. Brada and Ronald L. Graves developed the models being investigated in this thesis by adding variables to a model first developed by Paul Gregory. Gregory tested two hypotheses in generating his model. First, he hypothesized that real Soviet defense outlays depend on the aggregate level of output in the Soviet Union as measured by real Soviet GNP. Second, he hypothesized that the fraction of GNP devoted to defense was positively related to the level of defense outlays in the United States. It was explained in the previous chapter that Gregory believed that the relationship between United States and Soviet defense expenditures exists because the Soviet leadership is compelled to react to the changes in military capability of the United States. Converting the variables to natural logarithms, Gregory estimated the following model:

$$\log SD_t = a + b_1 \log USD_t + b_2 \log SY_t + e_t \qquad (1)$$

where:

SD_t = real Soviet defense outlays in year t

USD_t = real United States defense expenditures in year t

SY_t = real Soviet GNP in year t

e_t = error term.

The regression results that Gregory obtained from Equation (1), using the data in Appendix A, are given below.

Regression Results

constant (a)	logUSD (b_1)	logSY (b_2)	Coefficient of multiple determination (R^2) = 0.83. Standard error = 0.10. t values are given below their respective coefficients in parentheses.
-4.28	0.593	0.708	
(7.82)	(2.72)	(8.68)	

Dependent variable: log SD.

The regression results suggest that both U.S. defense expenditures and the magnitude of Soviet GNP exert positive and significant impacts on the level of Soviet defense expenditures. As can be seen from the large t-values (2.72 and 8.68), both variables are significant at the 0.05 level. Because the regression model is in double-logarithm form, the individual coefficients show the percentage change in the dependent variable (SD) brought about by a given percentage change in the explanatory variable (USD or SY). Thus, the model suggests that a 1% increase in U.S. defense expenditures will bring about a 0.59% change in Soviet defense expenditures in the same direction.

Three tests were performed on the model to determine whether alternative models and variable specifications might provide a better explanation of Soviet defense expenditures.

First, an attempt was made to determine the timing of the impact of U.S. defense expenditures on SD. In other words, do Soviet defense expenditures depend on this year's U.S. defense spending, on last year's, etc., or on some combination of current and past expenditures? Statistically, the issue may be investigated by entering USD in lagged form. Gregory limited his investigation to a three-year maximum lag and entered USD_1, USD_2, and USD_3 in addition to current USD as explanatory variables. The bottom line is that the original unlagged simple model (Equation (1)) provides an explanation of Soviet defense spending as good as or better than the more complicated dynamic lagged models estimated. Gregory suggests that the Soviets are responding to forecasts of United States defense expenditures rather than to actual amounts.

The second test was to determine whether Soviet defense expenditures tend to respond to real U.S. defense expenditures (in constant dollars) as originally postulated in model (1) or, in a less sophisticated manner, to U.S. defense expenditures in current dollars unadjusted for price increases in the defense sector. To test this particular issue, Gregory re-estimated model (1) and the lagged models described immediately above by substituting U.S. defense expenditures in current dollars for real U.S. defense expenditures. It was noted by Gregory that the original model tends to explain Soviet defense expenditures better than the re-estimated current dollar model.

The third and final test was to determine to what extent the results in model (1) simply indicate a common upward time trend affecting both the dependent and explanatory variables in a common manner. The way to deal with this question is to eliminate the time trend by redefining the original variables as first differences (annual changes) rather than in absolute terms as was done in model (1). Thus, a ΔSD, for example denotes the positive or negative annual change in real Soviet defense expenditures. Similarly, other variables in model (1) are ΔUSD and ΔSY. The estimated first-difference regressions are recorded below.

$$\Delta SD = 0.082 + 0.055\Delta USD - .003\Delta SY \quad R^2 = 0.11$$

(1.96) Standard error = 0.087

$$\Delta SD = 0.054 + 0.054\,\Delta USD \quad R^2 = 0.16$$

(2.02) Standard error = 0.084

While Soviet GNP (SY) accounted for a substantial portion of the variation in SD in model (1), its rate of change (ΔSY) failed to exert a statistically significant influence on the rate of change of Soviet defense expenditures (ΔSD). I assume that Gregory did not show a t-statistic in his regression for ΔSY because 0.003 exerts such little influence on the variable that it makes no difference whether the variable itself is significant. Rather, the important variable explaining variation in the rate of change of Soviet defence expenditures is the rate of change of U.S. defense expenditures. This can be seen from the estimated first-difference regressions above. The conclusion to be drawn from Gregory's models is that the growing size of the Soviet economy does tend to pull up Soviet defense expenditures over the long run, but that short-term variation around this rising trend is caused not by variation in the rate of economic growth but by variation in U.S. defense spending.

In a replication of the Gregory regressions, I came up with different parameter estimates (Appendix A). In Equation (1) replication all the parameters are lower and the USD variable is not significant at the 0.10 level. In the replication of the estimated first-difference regressions, the constant differs by a factor of ten and the R^2 is more relevant. These differences were probably due to a misprint in the data or to a step that was not shown, such as the conversion of dollars to rubles or of the old ruble rate to the new ruble rate.

Equation (1) is the Gregory model and is the foundation of the Brada and Graves study. It will be referred to as model (1).

The second model deals with the hypothesis that there has been a spillover of technical and managerial problems from the civilian economy to the defense sector. As stated in the previous chapter, difficulties in the civilian sector are alleged to be slowing down the growth of aggregate factor productivity thereby reducing the ability of Soviet defense firms to develop and produce new weapons systems, and lowering procurement below desired levels. Using this hypothesis, Brada and Graves assumed that the time-path of factor productivity growth in all industry reflects the time-path of factor productivity growth in the defense sector. Thus Soviet defense expenditures can be explained as follows:

$$\log SD_t = a + b_1 \log USD_t + b_2 \log SY_t + b_3 \log SFP_t + e_t \qquad (2)$$

where:

SFP = the growth of Soviet factor productivity in industry determined by an equation using the percent change in Soviet industrial production, employment, and capital stock.

The final two models developed by Brada and Graves bring in to play the variable of the strategic gap between the

Soviet Union and the United States, measured by nuclear warheads that each side could deliver. According to Brada and Graves, this variable can also be used in the model to test if there was a change in Soviet leadership's demand for defense expenditures. The two models are as follows:

$$\log SD_t = a + b_1 \log USD_t + b_2 \log SY_t + b_3 \log SP_t + e_t \qquad (3)$$

and

$$\log SD_t = a + b_1 \log USD_t + b_2 \log SY_t + b_3 \log SFP_t + b_4 \log SP_t + e_t \qquad (4)$$

where:

SP_t = deliverable Soviet warheads/deliverable U.S. warheads.

In Equation (3) the effect of procurement problems is assumed not to exist, suggesting that only the achievement of strategic parity was instrumental in the change in Soviet defense expenditures. Equation (4) allows for the possibility that both procurement problems and the achievement of strategic parity have influenced Soviet decisions on the share of GNP devoted to defense.

The measurement of strategic parity is a difficult issue since it depends on both nuclear and non-nuclear forces. The measure of parity used in the Brada-Graves study, the number of warheads, is crude since the power of nuclear weapons depends on the reliability and accuracy of the delivery system, the yield of the warhead and the intended target (cities vs. missiles). Nevertheless, to the extent that the yield of U.S. weapons was smaller while Soviet warheads were larger but less accurate, the use of number of warheads reflects some of these qualitative differences more effectively than would, for example, a comparison of delivery vehicles or yields.

IV. DATA PRESENTATION

The data used in the replication of the Brada and Graves study is contained in Appendix B. The estimates for the data on Soviet defense expenditures were provided by the Central Intelligence Agency (CIA). The CIA estimates are considered more applicable than other independent estimates for two reasons. First, there is a clearcut methodology and they have access to data generally not available to others. Second, the CIA estimates play a primary role in the United States government's assessment of Soviet defense policies and intentions and therefore play a major role in setting U.S. defense policy. The method that the CIA uses to construct the value of Soviet military expenditures is through a building-block approach. Every new element of the Soviet military force is valued at the price that it would have if purchased in the United States. The objective is not to establish the basis for international comparison but to produce a summary indicator of the value of the Soviet military effort in U.S. terms. This method of calculating Soviet defense expenditures has some inadequacies. For example, when the U.S. increased military pay in 1971 to accomodate the coming of the all volunteer force it elicited an artificial yet substantial increase in the CIA estimate of Soviet defense expenditures [Ref. 3]. Also, applying high U.S. labor rates to the labor-intensive Soviet military can present a deceptively high estimate of Soviet defense expenditures. Because of the obvious distortions that can be created by this estimating procedure, the CIA no longer reports its estimates in this manner. The 1988 edition of "World Military Expenditures and Arms Transfers" reports Soviet defense expenditures through 1984. Also, the Rand Corporation's "Military Spending in Eastern Europe" of 1987 reports Soviet defense expenditures only through 1983. Therefore, 1984 is the last year used in this study because of the four year lag in reporting.

The first step in the replication of the Brada and Graves study was to run regressions on the 25 years of data using the following models:

$$\log SD_t = a + b_1 \log USD_t + b_2 \log SY_t + e_t \qquad (1)$$

$$\log SD_t = a + b_1 \log USD_t + b_2 \log SY_t + b_3 \log SFP_t + e_t \qquad (2)$$

$$\log SD_t = a + b_1 \log USD_t + b_2 \log SY_t + b_3 \log SP_t + e_t \qquad (3)$$

$$\log SD_t = a + b_1 \log USD_t + b_2 \log SY_t + b_3 \log SFP_t + b_4 \log SP_t + e_t \qquad (4)$$

The next step was to determine if the regression results were appropriate for the entire sample period. To do this, I used a likelihood ratio, a chi-squared test, and a Chow test to determine whether the sample period can be better described by a single regression regime or by two separate regressions, each with the same specification but with different parameter estimates.

The likelihood ratio used is:

lambda = ((standard error of left side estimate)^T * (standard error of right side estimate)^t)/(standard error of total estimate)$^{T+t}$,

where:

T = the number of years to the estimated location of the unknown switching point

t = total number of years in the original regression--T.

In the likelihood ratio test, lambda is minimized.

The procedure in using the likelihood ratio is as follows. All possible divisions of the entire sample are placed into a left-hand and a right-hand group. The left-hand group runs from 1960 to the year of the estimated break (T-years) and the right-hand group runs from the estimated year of the break + 1 to 1984 (t-years). A regression is then run on each sample. The smallest sample that can be used for a regression is n+2, where n equals the number of variables. Therefore the first estimated break for model

(1) is 1963 (T = 4 and t = 21). The second break is estimated to be at 1964 (T = 5 and t = 20). This process is continued for model (1) until T = 21 and t = 4. The standard error from each regression is inserted into the likelihood ratio and where lambda is minimized, the location of the <u>possible</u> break is determined. This procedure is performed on each model with the only difference being that three variables need a sample size of at least five and four variables need a sample size of at least six.

At this point we have determined that if there is a break in the regression we know its location. The next step is to run a chi-square test to test the hypothesis that no break has taken place.

The chi-square distribution with 4 degrees of freedom is an acceptable approximation to the distribution of -2 log lambda [Ref. 4]. In their study, Brada and Graves simply multiplied the minimized lambda of the likelihood ratio by -2 log lambda and determined its significance using the chi-square distribution with 4 degrees of freedom plus the number of variables used. For example the degrees of freedom for model (1) is 6. If the product of -2 log lambda and the minimal likelihood ratio is significant it will disprove the hypothesis that there is no break in the regression estimate.

If there actually is a break in the regression, as determined by the chi-squared test, the next and final process is to determine whether the coefficients for the pre-break period are significantly different from those of the post-break period. This is done with the use of the Chow test [Ref. 5].

The method involved can be described very simply. Suppose that n observations are used to estimate a regression with p parameters (p-1 coefficients plus one intercept). Suppoae also that there are m additional observations, and we are interested in deciding whether they are generated by the same regression model as the first n observations. Performing the analysis of covariance requires the following sums of squares:

1. A, the sum of squares of n + m deviations of the dependent variable from the regression estimated by n + m observations, with n + m - p degrees of freedom.

2. B, the sum of squares of n deviations of the dependent variable from the regression estimated by the first n observations, with n - p degrees of freedom.

3. C, the sum of squares of m deviations of the dependent variable from the regression estimated by the second m observations, with m - p degrees of freedom.

The ratio of $(A - B - C)/p$ to $(B + C)/(n + m - 2p)$ will be distributed as $F(p, n + m - 2p)$ under the null hypothesis that both groups of observations belong to the same regression model.

As an example, in model (1) A is equal to the error sum of squares for the entire regression (data from 1960-1984), B is equal to the error sum of squares of T years of data as determined by the likelihood ratio and the chi-squared test

(T = n observations in the Chow ratio), and C is equal to the error sum of squares of t years of data (break + 1 to 1984) which is equal to m observations in the Chow ratio. p is equal to 3 (intercept plus two variables). The significance can then be determined by comparing the Chow ratio with the F distribution where p and (n + m -2p) are the degrees of freedom.

In the next step, all of the tests were performed on the data, but instead of having a high and a low estimate of Soviet defense expenditure a mean of the two was used. The results were then compared to the replication of the Brada and Graves study.

The final process of this study involved the replacement of the Growth of Soviet Factor Productivity variable with a Warsaw Pact ratio of defense expenditures to GNP. The data included was from 1965-1984. All the same tests were run and the results were compared. Data used in this final process are also included in Appendix B.

V. RESULTS

A. REPLICATION AND MEAN DEPENDENT VARIABLE

Tables I and II are the parameter estimates for the Brada and Graves study using the CIA's low and high estimates for Soviet defense expenditures. Tables III and IV are the results of a replication of their study. Table V is the parameter estimates using the mean of the low and high estimates of the Soviet defense expenditures. For equations using low estimates of Soviet defense expenditures

TABLE I

PARAMETER ESTIMATES FOR EQUATIONS SDL, 1960-1984

Variable	Model (1)	Model (2)	Model (3)	Model (4)
Constant	-3.2863 (-6.712)*	-3.1857 (-6.494)*	-3.8596 (-5.719)*	-4.0347 (-6.284)*
log USD	0.1432 (2.151)**	0.1500 (2.273)**	0.1744 (2.468)**	0.2033 (2.981)*
log SY	1.0620 (30.496)*	1.0401 (26.875)*	1.1244 (18.239)*	1.1262 (19.398)*
log SFP		-0.0091 (-1.239)		-0.0143 (-1.919)**
log SP			-0.0370 (-1.220)	-0.0584 (-1.906)**
R^2	0.9799	0.9828	0.9828	0.9854

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

TABLE II

PARAMETER ESTIMATES FOR EQUATIONS SDH, 1960-1984

Variable	Model (1)	Model (2)	Model (3)	Model (4)
Constant	-2.8811 (-5.399)*	-2.6610 (-5.641)*	-1.9920 (-2.812)*	-2.2021 (-3.364)*
log USD	0.1046 (1.442)	0.1196 (1.885)***	0.0562 (0.758)	0.0909 (1.307)
log SY	1.0661 (28.086)*	1.0181 (27.357)*	0.9694 (14.981)*	0.9715 (16.413)*
log SFP		-0.0200 (-2.820)*		-0.0172 (-2.259)**
log SP			0.0573 (1.802)***	0.0316 (1.011)
R^2	0.9767	0.9823	0.9789	0.9824

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

(SDL), Table I, the parameter estimates for United States defense expenditures (USD) and for Soviet GNP(SY) are significant in all specifications and are relatively stable. A one percent increase in United States defense outlays yields an increase of 0.14-0.20 percent in Soviet defense expenditures. The elasticity of defense outlays with respect to Soviet GNP is significantly greater than zero in all specifications. Soviet factor productivity (SFP) is significant in model (4), but with a negative sign. This indicates that the slowdown in industrial productivity has had no negative effect on defense outlays. It could even

TABLE III

REPLICATION FOR EQUATIONS SDL, 1960-1984

Variable	Model (1)	Model (2)	Model (3)	Model (4)
Constant	-3.2864 (-6.71)*	-3.1847 (-6.70)*	-3.8597 (-5.72)*	-3.0712 (-6.89)*
log USD	0.1432 (2.15)**	0.1609 (2.48)**	0.1744 (2.47)**	0.2297 (3.49)*
log SY	1.0621 (30.50)*	1.0310 (26.84)*	1.1244 (18.24)*	1.1295 (20.74)*
log SFP		-0.0148 (-1.65)		-0.0235 (2.64)**
log SP			-0.0370 (-1.22)	-0.0692 (2.35)**
R^2	0.982	0.984	0.983	0.987

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

mean that increased defense outlays may be the cause of a decline in productivity in the civilian economy, or that a fall in the opportunity cost of investing in defense causes more to be invested in defense. The strategic parity variable is significant only in model (4) and has a negative sign. Therefore, the closer the Soviet Union comes to strategic parity with the United States, the lower are Soviet defense outlays.

Table II results for the high estimate of Soviet defense expenditures (SDH) differ only slightly from those in Table I. There is a general lack of significance of the USD

TABLE IV

REPLICATION FOR EQUATIONS SDH, 1960-1984

Variable	Model (1)	Model (2)	Model (3)	Model (4)
Constant	-2.8812 (-5.40)*	-2.6875 (-6.06)*	-1.9921 (-2.81)*	-2.3565 (-3.72)*
log USD	0.1046 (1.44)	0.1383 (2.28)**	0.0562 (0.76)	0.1158 (1.69)
log SY	1.0661 (28.09)*	1.0070 (28.11)*	0.9694 (14.98)*	0.9749 (17.22)*
log SFP		-0.02818 (-3.38)*		-0.0253 (-2.73)**
log SP			0.0573 (1.80)***	0.0226 (0.74)
R^2	0.979	0.986	0.982	0.987

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

variable which means that it is not as useful as a predictor of Soviet defense expenditures. Also, there is a lower elasticity of defense outlays with respect to SY. The sign of SFP is negative for SDH as it was for SDL. An interesting difference is that the coefficient for SP is positive. This means that the closer the Soviets are to achieving strategic parity with the United States, the more resources they devote to defense. This can be interpreted as a more competitive behavior than the results of SDL.

Tables III and IV, the replication, indicate the same results as Tables I and II. The only difference is the

TABLE V

PARAMETER ESTIMATES FOR EQUATIONS SDM, 1960-1984

Variable	Model (1)	Model (2)	Model (3)	Model (4)
Constant	-3.0712	-2.9185	-2.8275	-3.1793
	(-6.66)*	(-7.30)*	(-4.33)*	(-5.55)*
log USD	0.1223	0.1489	0.1091	0.1666
	(1.95)**	(2.72)**	(1.60)	(2.69)**
log SY	1.0645	1.0179	1.0380	1.0432
	(32.47)*	(31.50)*	(17.40)*	(20.36)*
log SFP		-0.0222		-0.0245
		(-2.95)*		(-2.92)*
log SP			0.0157	-0.0178
			(0.54)	(-0.64)
R^2	0.984	0.989	0.984	0.989

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

slightly different outcomes when the Soviet factor productivity (SFP) variable was used. This difference was not significant and caused no change in the conclusions.

Table V displays the parameter estimates for the equations using the mean of the estimated Soviet defense expenditures as the dependent variable. The USD variable is significant in all four equations and therefore is a useful predictor of Soviet defense expenditures. As with Table I, the elasticity of defense outlays with respect to Soviet GNP is significantly greater than zero in all specifications. The coefficient on Soviet factor productivity, SFP, is significantly negative in model (2) and model (4). This further strengthens the argument that the slowdown in industrial productivity has had no negative effect on defense outlays. The major difference in Table V is that the strategic parity variable is not significant in model (3) or model (4). This suggests that attitudes toward strategic parity by Soviet leaders had no effect on Soviet defense expenditures.

From the first five tables it can be concluded that Soviet defense expenditures are clearly related to Soviet GNP and, in the case of SDL and SDM, to United States defense expenditures, in the same way as assumed by Gregory. The results also indicate, for the sample period used, that Soviet factor productivity growth in industry by way of lower opportunity costs has also been an important determinant of Soviet defense outlays, but opposite to the way it was postulated. In the case of the strategic balance between the Soviet Union and the United States, the effect on defense expenditures differs. For SDL, expenditures are lowered as parity is neared. For SDH expenditures are increased as parity is neared. For SDM, nearing parity has no significant effect on defense expenditures.

The next step was to determine if the regression results were appropriate for the entire sample period or if there had been a change in Soviet attitudes toward defense outlays during the sample period.

Brada's and Graves's results for the three tests performed to determine if and where there was a break in the regressions are reported in Table VI. Again, a replication of the Brada and Graves tests was performed. The only difference was that the Chi-squared and Chow test results in the replication for models that included Soviet factor productivity growth in industry, SFP, were insignificantly different from those in the Brada and Graves study and still

TABLE VI

TESTS FOR STRUCTURAL BREAKS

Dependent Variable	Explanatory Variables	Year of Break	Chi-squared Test	Chow Test
SDL	USD,SY	1965	CHI-SQ(6)=23.361	F(3,19)=9.249
SDL	USD,SY,SFP	1969	CHI-SQ(7)=25.644	F(4,17)=7.111
SDL	USD,SY,SP	1976	CHI-SQ(7)=35.675	F(4,17)=1.224
SDL	USD,SY, SFP,SP	1976	CHI-SQ(8)=33.436	F(5,15)=1.297
SDH	USD, SY	1969	CHI-SQ(6)=21.287	F(3,19)=7.563
SDH	USD,SY,SFP	1972	CHI-SQ(7)=24.182	F(4,17)=9.469
SDH	USD,SY,SP	1976	CHI-SQ(7)=31.094	F(4,17)=3.853
SDH	USD,SY, SFP,SP	1973	CHI-SQ(8)=44.950	F(5,15)=4.461
SDM	USD, SY	1965	CHI-SQ(6)=14.638	F(3,19)=6.529
SDM	USD,SY,SFP	1969	CHI-SQ(7)=16.700	F(4,17)=4.819
SDM	USD,SY,SP	1976	CHI-SQ(7)=33.005	F(4,17)=1.991
SDM	USD,SY, SFP,SP	1976	CHI-SQ(8)=27.657	F(5,15)=1.262

lead to the same conclusions. Therefore, the results of the replication of tests to determine if there are breaks in the regressions are not shown.

The Year of Break column indicates the last year of the first period that was determined by the likelihood ratio. The likelihood ratio only determined where the break would occur if there actually was a break. The Chi-squared test determined if there actually was a break, and the Chow test determined if the break was significant.

In the Brada and Graves study the tests indicated the presence of a structural break in the regression regime for all specifications and for both SDL and SDH. The Chow test generally confirmed that significant differences exist between the regression coefficients of the pre- and post-break samples despite the small sample size and high collinearity. This leads to the conclusion that the use of the regression results reported in Tables I and II to explain Soviet defense expenditures over the entire sample period is not appropriate. Also, the structural breaks occur when SFP and SP are included as explanatory variables, which means that the achievement of strategic parity with the United States and the difficulties experienced by the Soviet economy by themselves cannot explain the slowdown in Soviet defense expenditures. The relationship between Soviet defense expenditures and the explanatory variables changed at some point within the sample period, indicating either a change in military doctrine or a change in the leaders' preferences. There are three cases where the break occurs in the 1960s. In all three cases not all explanatory variables are included in the specification, and Brada and Graves believe that these breaks reflect the effects of missing variables.

The tests for structural breaks using SDM produce the same results as the tests using SDL. One result that Brada and Graves did not point out, and which also showed up in the structural break tests using SDM, is that, according to my calculations, the Chow test for SDL model (3) and (4) is not significant. This would indicate that although there is a structural break at 1976, the pre- and post-break regressions are not all that different.

Tables VII, VIII, and IX report parameter estimates obtained by estimating models (1)-(4) over the two sample periods as determined in Table VI.

The replication of the Brada and Graves study for parameter estimates on the basis of structural breaks will not be discussed because the results confirm the outcome of the Brada and Graves study. There were some insignificant defferences in the estimates for models (2) and (4), but they did not change any of the conclusions.

Some basic conclusions can be drawn from Tables VII-IX. For SDL all specifications show a decrease in the elasticity of Soviet defense expenditures with respect to Soviet GNP

TABLE VII

PARAMETER ESTIMATES FOR EQUATIONS EXPLAINING SDL
ESTIMATED ON THE BASIS OF STRUCTURAL BREAKS

	Model (1)		Model (2)	
Variable	1960-65	1966-84	1960-69	1970-84
Constant	-13.863 (-2.877)***	-2.925 (-8.069)*	-3.780 (-1.557)***	-2.741 (-7.168)*
log USD	1.181 (1.751)	0.115 (3.061)*	0.232 (0.154)	0.047 (1.186)
log SY	1.975 (6.007)*	1.027 (30.570)*	1.089 (4.589)*	1.053 (22.698)*
log SFP			-0.100 (-0.058)	-0.004 (-1.204)
R^2	0.9290	0.9883	0.9718	0.9869

	Model (3)		Model (4)	
Variable	1960-76	1977-84	1960-76	1977-84
Constant	-4.649 (-5.174)*	2.127 (3.923)**	-4.278 (-5.113)*	2.124 (3.263)**
log USD	0.258 (2.607)**	0.151 (5.080)**	0.245 (2.719)**	0.151 (4.399)**
log SY	1.173 (15.841)*	0.204 (1.922)***	1.134 (16.188)*	0.204 (1.638)***
log SFP			-0.039 (-1.953)**	-0.000 (-0.016)
log SP	-0.087 (-1.738)***	0.174 (12.956)*	-0.068 (-1.451)***	0.174 (10.216)*
R^2	0.9714	0.9982	0.9783	0.9982

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

TABLE VIII

PARAMETER ESTIMATES FOR EQUATIONS EXPLAINING SDH ESTIMATED ON THE BASIS OF STRUCTURAL BREAKS

Variable	Model (1) 1960-69	Model (1) 1970-84	Model (2) 1960-72	Model (2) 1973-84
Constant	-2.187	-5.024	-2.217	-5.109
	(-2.891)**	(-11.571)*	(-5.507)*	(-8.795)*
log USD	0.0001	0.143	0.208	0.053
	(0.000)	(2.867)**	(2.686)**	(0.546)
log SY	1.045	1.379	0.871	1.467
	(6.997)*	(28.730)*	(20.373)*	(11.479)*
log SFP			-0.079	-0.004
			(-4.231)*	(0.689)
R^2	0.9345	0.9859	0.9846	0.9789

Variable	Model (3) 1960-76	Model (3) 1977-84	Model (4) 1960-73	Model (4) 1974-84
Constant	-2.474	0.253	-2.141	-0.1683
	(-3.205)*	(0.222)	(3.931)*	(-0.068)
log USD	0.099	0.191	0.173	0.252
	(1.162)	(3.045)**	(2.516)**	(1.965)***
log SY	0.990	0.512	0.889	0.525
	(15.581)*	(2.296)***	(18.266)*	(1.128)
log SFP			-0.075	-0.001
			(-3.782) **	(-0.281)
log SP	-0.041	0.203	-0.000	0.139
	(-0.954)	(7.163)	(-0.025)	(1.950)***
R^2	0.9735	0.9960	0.9797	0.9714

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

TABLE IX

PARAMETER ESTIMATES FOR EQUATIONS EXPLAINING SDM ESTIMATED ON THE BASIS OF STRUCTURAL BREAKS

	Model (1)		Model (2)	
Variable	1960-65	1966-84	1960-69	1970-84
Constant	-11.827	-3.7819	-2.9482	-3.8521
	(-2.85)***	(-8.57)*	(-5.15)*	(-9.40)*
log USD	1.0710	0.1626	0.2347	0.1093
	(1.84)	(3.55)*	(1.35)	(2.54)**
log SY	1.7369	1.1454	0.9570	1.2010
	(6.13)*	(28.00)*	(7.17)*	(23.08)*
log SFP			-0.0861	-0.0076
			(-3.01)**	(-1.51)
R^2	0.931	0.986	0.974	0.989

	Model (3)		Model (4)	
Variable	1960-76	1977-84	1960-76	1977-84
Constant	-3.442	1.0545	-3.0910	1.1813
	(-4.23)*	(1.51)	(-4.18)*	(1.39)
log USD	0.1694	0.1736	0.1573	0.1706
	(1.89)***	(4.53)*	(1.98)***	(3.89)*
log SY	1.0708	0.3785	1.0332	0.3612
	(15.98)*	(2.77)**	(16.69)*	(2.26)***
log SFP			-0.0362	0.0009
			(-2.14)***	(0.40)
log SP	-0.0614	0.1902	-0.0427	0.1955
	(-1.35)	(10.95)*	(-1.03)	(8.3)*
R^2	0.973	0.998	0.981	0.998

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

from the first period to the second. For SDH the elasticity of Soviet defense expenditures with respect to USD is higher in the post-break period rather than lower. For SDM the first two models have an increasing elasticity for USD because of insignificant pre-break parameters, while the last two models show an increasing elasticity with both pre-break and post-break parameters being significant. SFP tends not to play a significant role in determining the level of SDL except in model (4) where it is significant only at the 10% level for the pre-break period. On the other hand, Strategic parity is generally significant. An interesting outcome is that in all the Tables SP is negative in the pre-break period and positive in the post-break period. This would suggest that before the break the Soviet Union reduced defense expenditures as its number of nuclear weapons increased relative to that of the United States and that the Soviet Union was only seeking strategic parity with the United States. But after the break the higher the ratio of Soviet to United States warheads, the greater the Soviet defense expenditures. This could reflect a change in the Soviet strategy to one of being more competitive.

To summarize, the only major difference in the three tables is that in the SDL table the elasticity of Soviet defense expenditures with respect to USD tends to decrease inthe post-break period while it tends to increase in the

SDH table. In the SDM table the elasticity decreases in the first two models and increases in the last two. This suggests that a change in the views of Soviet leadership toward strategic parity had an effect on the elasticity of Soviet defense expenditures with respect to United States defense expenditures. Another important conclusion that can be drawn is that Soviet attitudes toward defense outlays changed sometime in the mid-1970s so that the expenditures became less responsive to the growth rate of Soviet GNP. Using the mean of the Soviet defense expenditures and working through the models gives more credibility to these conclusions.

Brada and Graves produced the results of projections and the actual level of Soviet defense expenditures in their study but made an error by reversing the year of the break for SDL and SDH in their table. Conclusions were made from a SDL break in 1973 that should have been 1976 and a SDH break in 1976 should have been 1973. Therefore, the results are not entirely accurate.

The level of Soviet defense outlays for the post-break period, 1977-1984, using the pre-break parameters and the post-break parameters for Equation (4), as reported in Table IX, were computed to show the implications of changes in attitude for Soviet defense expenditures. The results of the projections and the actual level of Soviet defense expenditures are reported in Table X. This table was

TABLE X

COMPARISON OF ACTUAL AND ESTIMATED SOVIET DEFENSE EXPENDITURES AFTER THE STRUCTURAL BREAK FOR MODEL (4) SDM

Year	Actual	Calculated on Basis of Pre-Break Coefficients	Calculated on Basis of Post-Break Coefficients
1977	63.0	62.74	62.98
1978	64.5	65.29	64.38
1979	67.0	69.49	67.36
1980	70.5	69.22	70.66
1981	73.0	69.81	72.59
1982	74.0	77.50	73.82
1983	77.0	72.79	77.26
1984	78.5	74.60	78.52

computed and conclusions were drawn even though the Chow test was insignificant. An insignificant Chow test would indicate that although a change took place it would only have a negligible effect. The table was produced and discussed to form a comparison with the Brada and Graves study.

Projections based on the pre-break coefficients show what Soviet defense spending would have been had the leadership's attitudes toward such outlays not changed. Generally the mean actual expenditures are higher than the pre-break coefficient projections, which indicates a change toward increased spending. This means that although there was a definite break in the regression, the variables used do not show a decrease in expenditures but rather a change to a more hawkish attitude by the Soviet leaders. Projections based on the post-break coefficients are the model's predictions of Soviet defense outlays reflecting the altered Soviet decisionmaking process. There is a very close fit between the mean of the CIA's estimates of SDL and SDH and the projections based on post-break coefficients. Also important is that the estimates based on post-break coefficients represent a much more stable pattern of defense expenditures than do the estimates based on pre-break coefficients. This should prove very soundly that the mean of the high and low defense expenditure estimates for the period 1960-1984 can be used to show a change in Soviet leaders' attitude toward a more hawkish policy involving defense expenditures.

B. MODIFICATION OF INPUT DATA

In Part A, Soviet factor productivity was found not to be a cause of the slowdown in the growth of Soviet defense expenditures. This study was therefore performed again with the variable of Warsaw Pact (less Soviet) defense expenditures (WPD) used in place of SFP. Because of the inability to get all the necessary data the test period is from 1965-1984. WPD is actually the Warsaw Pact (less Soviet) defense expenditures divided by Warsaw Pact (less Soviet) GNP [Ref. 6]. Using a ratio provides a consistent variable to be used in the models. After performing all the tests with current year WPD and again with a one year lag, I found that a one year lag of WPD gave a better fit in that the coefficient of determination (R^2) was higher in the one year lag WPD.

Tables XI, XII, and XIII give the parameter estimates for models (1) through (4) for SDL, SDH, and SDM. It is noteworthythat WPD is significant in all specifications at the 1% level. Also, SP is generally not a significant predictor of Soviet defense expenditures in any of the models. The elasticity of defense outlays with respect to Soviet GNP is significantly greater than zero in all specifications of SDH and SDM. The sign for SP was different in all three tables, but because of its insignificance no conclusions were drawn.

The next step was to determine, using the likelihood ratio, chi-squared, and Chow tests, if there were any breaks in the regressions. The results are displayed in Table XIV. The Chi-squared test indicates that there was a structural break in all the regressions except for SDH when only USD and SY variables were used. This adds credence to the previous determination that the break is basically determined by the variable SP.

Tables XV through XVII show parameter estimates obtained by estimating models (1)-(4) over the two sample periods as determined in Table XIV. All specifications show a decrease

TABLE XI

PARAMETER ESTIMATES FOR EQUATIONS SDL, 1966-1984

Variable	Model (1)	Model (2)	Model (3)	Model (4)
Constant	-2.9251	-2.8847	-2.5018	-3.5214
	(-8.07)*	(-9.47)*	(-3.22)*	(-4.79)*
log USD	0.11524	0.1033	0.09118	0.13727
	(3.06)*	(3.24)*	(1.67)***	(2.86)*
log SY	1.02664	0.95571	0.98014	1.01031
	(30.57)*	(25.11)*	(11.88)*	(14.65)*
log WPD		-0.16025		-0.19722
		(-2.77)*		(-2.83)*
log SP			-0.01617	-0.02468
			(-0.62)	(-0.95)
R^2	0.988	0.992	0.989	0.993

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

in the elasticity of Soviet defense expenditures with respect to United States defense expenditures. The elasticity of Soviet defense expenditures with respect to Soviet GNP is erratic as far as increasing or decreasing in the post-break period but is still generally significant in all specifications. An important point is that WPD is generally significant and also changes its elasticity from positive to negative in the models where both pre-break and post-break WPD was significant. This indicates that in the pre-break period the Soviets increased their defense spending as the block countries spending increased. But

TABLE XII

PARAMETER ESTIMATES FOR EQUATIONS SDH, 1966-1984

Variable	Model (1)	Model (2)	Model (3)	Model (4)
Constant	-4.4379 (-8.23)*	-4.3730 (-10.07)*	-3.810 (-3.30)*	-5.468 (-5.429)*
log USD	0.19870 (3.55)*	0.17953 (3.95)*	0.16298 (2.01)**	0.23794 (3.53)*
log SY	1.23895 (24.79)*	1.12510 (20.74)*	01.1699 (9.53)*	1.21901 (12.59)*
log WPD		-0.25717 (-3.12)*		-0.32073 (-3.27)*
log SP			0.02399 (0.62)	0.04243 (1.17)
R^2	0.981	0.989	0.982	0.990

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

after the break, Soviet defense spending decreased when the Soviet block countries' defense expenditures increased. This shows that Soviet leaders decided to let the block countries carry a larger burden of the defense needs. The last major point is that in all the pre-break periods the Soviets reduced defense spending as they neared strategic parity with the United States, but in the post-break period they increased defense expenditures as they neared parity. This reflects a change to a more competitive policy on the part of Soviet leadership.

TABLE XIII

PARAMETER ESTIMATES FOR EQUATIONS SDM, 1966-1984

Variable	Model (1)	Model (2)	Model (3)	Model (4)
Constant	-3.7819 (-6.57)*	-3.7279 (-10.62)*	-3.2472 (-3.44)*	-4.6231 (-5.54)*
log USD	0.16261 (3.55)*	0.14665 (3.99)*	0.13222 (1.99)**	0.19441 (3.57)*
log SY	1.14542 (28.00)*	1.05062 (23.95)*	1.0867 (10.83)*	1.12740 (14.41)*
log WPD		-0.21416 (-3.22)*		-0.26613 (-3.36)*
log SP			0.02042 (0.64)	-0.03469 (-1.18)**
R^2	0.986	0.992	0.986	0.992

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

The final table is a comparison of the actual and estimated Soviet defense expenditures calculated on a pre-break and post-break basis for SDM. All the estimates are much closer to the actual defense expenditures when using the post-break coefficients. More important, all of the pre-break estimates were lower than the actual mean dependent variable: this suggests that the change in attitude of the Soviet leaders caused an increase in defense spending. In the post-break period for the low estimated dependent variable, however, the growth of defense

TABLE XIV

TESTS FOR STRUCTURAL BREAKS

Dependent Variable	Explanatory Variables	Year of Break	Chi-squarted Test	Chow Test
SDL	USD,SY	1969	CHI-SQ(6)=33.743	F(3,19)=4.939
SDL	USD,SY,SFP	1979	CHI-SQ(7)=33.930	F(4,17)=0.532
SDL	USD,SY,SP	1976	CHI-SQ(7)=32.603	F(4,17)=8.532
SDL	USD,SY, SFP,SP	1976	CHI-SQ(8)=27.528	F(5,15)=3.394
SDH	USD,SY	1980	CHI-SQ(6)=10.570	
SDH	USD,SY,SFP	1970	CHI-SQ(7)=34.916	F(4,17)=7.986
SDH	USD,SY,SP	1976	CHI-SQ(7)=15.851	F(4,17)=13.26
SDH	USD,SY, SFP,SP	1971	CHI-SQ(8)=13.793	F(5,15)=5.092
SDM	USD,SY	1980	CHI-SQ(6)=16.810	F(3,19)=1.711
SDM	USD,SY,SFP	1970	CHI-SQ(7)=27.058	F(4,17)=4.709
SDM	USD,SY,SP	1976	CHI-SQ(7)=26.003	F(4,17)=10.70
SDM	USD,SY, SFP,SP	1977	CHI-SQ(8)=20.518	F(5,15)=3.125

expenditures decreases in 1977 and 1978, increases from 1979 to 1982, and decreases in 1983 and 1984.

TABLE XV

PARAMETER ESTIMATES FOR EQUATIONS EXPLAINING SDL ESTIMATED ON THE BASIS OF STRUCTURAL BREAKS

	Model (1)		Model (2)	
Variable	1966-69	1970-84	1966-79	1980-84
Constant	-3.231 (-170.35)*	-2.936 (-8.32)*	-3.095 (-4.40)*	-0.427 (-1.40)
log USD	0.202 (70.32)*	0.047 (1.16)**	0.130 (2.23)**	0.015 (0.79)
log SY	1.000 (182.38)*	1.085 (27.81)*	0.994 (12.76)*	0.722 (11.57)**
log WPD			-0.104 (-0.60)	0.016 (2.88)
R^2	1.000	0.985	0.986	1.000

	Model (3)		Model (4)	
Variable	1966-76	1977-84	1966-76	1977-84
Constant	-5.423 (-4.33)*	2.126 (3.92)*	-5.680 (-4.27)*	1.595 (2.86)**
log USD	0.301 (3.32)*	0.151 (5.08)*	0.296 (3.18)*	0.151 (6.06)*
log SY	1.264 (9.99)*	0.204 (1.92)**	1.241 (9.31)*	0.272 (2.77)**
log WPD			-0.152 (-0.79)	-0.033 (-1.64)***
log SP	-0.079 (-2.21)**	0.174 (12.96)*	-0.079 (-2.13)**	0.155 (9.36)*
R^2	0.986	0.998	0.988	0.999

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

TABLE XVI

PARAMETER ESTIMATES FOR EQUATIONS EXPLAINING SDH ESTIMATED ON THE BASIS OF STRUCTURAL BREAKS

Variable	Model (1) 1966-80	Model (1) 1981-84	Model (2) 1966-70	Model (2) 1971-84
Constant	-3.447 (-3.50)*	-6.01 (-8.39)**	-1.349 (-163.64)*	-4.923 (-13.91)*
log USD	0.129 (1.50)***	-0.290 (-5.07)*	0.394 (223.06)*	0.141 (2.92)*
log SY	1.135 (12.05)*	1.90 (11.84)*	0.869 (773.93)*	1.283 (21.39)*
log WPD			0.720 (116.18)*	-0.178 (2.75)**
R^2	0.974	0.9859	1.000	0.991

Variable	Model (3) 1966-76	Model (3) 1977-84	Model (4) 1966-71	Model (4) 1972-84
Constant	-5.357 (-3.43)*	0.252 (0.22)	0.358 (0.48)	-4.708 (-3.72)*
log USD	0.287 (2.54)**	0.191 (3.04)**	0.176 (4.14)***	0.152 (2.00)**
log SY	1.295 (8.22)*	0.512 (2.30)**	0.577 (5.22)***	1.241 (8.63)*
log WPD			0.258 (1.77)	-0.175 (-1.67)***
log SP	-0.096 (-2.13)**	0.203 (7.16)*	0.069 (3.00)	0.007 (0.15)
R^2	0.980	0.996	0.999	0.988

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

TABLE XVII

PARAMETER ESTIMATES FOR EQUATIONS EXPLAINING SDM ESTIMATED ON THE BASIS OF STRUCTURAL BREAKS

	Model (1)		Model (2)	
Variable	1966-80	1981-84	1960-70	1971-84
Constant	-3.386	-3.880	-1.842	-4.029
	(-4.01)*	(-6.63)**	(-25.19)**	(-12.05)*
log USD	0.139	-0.169	0.378	0.097
	(1.88)**	(-3.61)***	(24.13)**	(2.41)**
log SY	1.100	1.438	0.863	1.171
	(13.64)*	(10.99)**	(86.63)*	(20.67)*
log WPD			0.529	-0.148
			(9.63)**	(-2.42)**
R^2	0.979	1.000	1.000	0.990

	Model (3)		Model (4)	
Variable	1966-76	1977-84	1966-77	1978-84
Constant	-5.393	1.055	-5.523	-2.064
	(-3.84)*	(1.51)***	(-4.01)*	(1.18)
log USD	0.293	0.1736	0.289	-0.018
	(2.89)**	(4.53)*	(2.92)**	(-0.14)
log SY	1.282	0.379	1.264	1.010
	(9.03)*	(2.77)**	(9.10)*	(2.67)**
log WPD			-0.092	-0.043
			(-0.45)	(-1.91)**
log SP	-0.088	0.190	-0.088	0.159
	(-2.19)**	(10.95)*	(-2.21)**	(8.32)*
R^2	0.983	0.998	0.987	0.999

Notes: t-ratio in parentheses
* significant at 1% level
** significant at 5% level
*** significant at 10% level.

TABLE XVIII

COMPARISON OF ACTUAL AND ESTIMATED SOVIET DEFENSE EXPENDITURES AFTER THE STRUCTURAL BREAK FOR MODEL (4) SDM

Year	Actual	Calculated on Basis of Pre-Break Coefficients	Calculated on Basis of Post-Break Coefficients
1978	64.5	63.23	64.56
1979	67.0	62.78	67.04
1980	70.5	64.37	70.79
1981	73.0	66.83	72.81
1982	74.0	70.63	74.03
1983	77.0	74.04	77.02
1984	78.5	77.06	78.66

VI. CONCLUSIONS

It was shown in this study, as well as in the Brada and Graves study, that Soviet defense expenditures have a decreasing dependence on Soviet GNP and on the level of United States defense expenditures, and that Soviet defense expenditures' dependence on the strategic balance between the Soviet Union and the United States changed in the mid-70s. This study went on further to show that the defense outputs of Soviet block countries also have an effect on Soviet defense expenditures. That is, prior to the mid-70s change in in Soviet leaders' attitude, as Soviet block countries' defense expenditures increased, so also did Soviet defense expenditures increase. But, after the break, as Soviet block countries' defense expenditures increased Soviet defense expnditures decreased. For further study there are a number of other variables that could be tested in the models, such as non-U.S. NATO defense espenditures or the ratio of non-Soviet WPD/non-U.S. NATO defense expenditures.

In the Brada and Graves study there was a difference in the outcomes for pre-break and post-break expenditures for the high and low dependent variable estimates. For the high estimates there was an indicated increase in defense expenditures for the post-break period. For the low estimate there was a decrease in defense expenditures for the post break period. Using a mean of the high and low input in the models resulted in an increase in defense expenditures for the post-break period.

In the tests using the Warsaw Pact defense expenditure variable, the post-break period showed an increase in defense expenditures for both the mean and high estimated inputs. However, for the low estimited dependent variable, the post-break period showed no consistent increase or decrease in defense expenditures. This was probably due to an unknown variable affecting the outcome of the models. This could also be a subject for further study.

The major point brought out by this study is that there was a change in the mid-70s in the attitude of the Soviet leadership regarding defense needs, but the variables used in showing this indicate an increase in defense expenditures rather than a decrease. Another difference between this and the Brada and Graves study is that this study determined that not just the view of Soviet leaders on strategic parity with the United States changed. What also changed was the Soviet attitude toward the sharing of defense responsibilities with the other Warsaw Pact countries. After the mid-70s, the Soviets bore a higher share of Warsaw Pact defense expenditures.

APPENDIX A

GREGORY DATA TABLE

YEAR	REAL SOVIET DEFENSE EXP. (MIL. RUBLES) SD	REAL U.S. DEFENSE EXP. (MIL. DOLLARS) USD	REAL SOVIET GNP (1950 PRICES) (MIL. OLD RUBLES) SY
1950	8.5	19.3	911.7
1951	9.5	42.3	1002.9
1952	11.3	56.5	1080.7
1953	11.3	59.8	1157.5
1954	11.4	49.3	1236.4
1955	11.4	44.5	1354.9
1956	10.6	44.0	1454.5
1957	11.0	46.1	1531.3
1958	11.1	45.9	1639.4
1959	11.4	45.0	1718.4
1960	11.5	43.1	1804.3
1961	14.3	45.4	1917.7
1962	15.7	48.9	1983.0
1963	17.2	47.0	2032.9
1964	17.3	44.6	2196.1
1965	17.1	43.4	2328.4
1966	18.4	51.5	2477.9
1967	19.9	59.6	2603.4

REGRESSION RESULTS - MODEL (1)

constant (a)	logUSD (b_1)	logSY (b_2)
-2.92	0.152	0.663
(4.54)	(1.27)	(7.36)

Dependent variable: logSD

Coefficient of multiple determination (R^2) = 0.83.

t values are given below their respective coefficients in parentheses. Standard error = 0.11.

CHANGE IN SD	CHANGE IN USD	CHANGE IN SY
1.0	23.0	91.2
1.8	14.2	77.8
0.0	3.3	76.8
0.1	-10.5	78.9
0.0	-4.8	118.5
-0.8	-0.5	99.6
0.4	2.1	76.8
0.1	-0.2	108.1
0.3	-0.9	79.0
0.1	-1.9	85.9
2.8	2.3	113.4
1.4	3.5	65.3
1.5	-1.9	49.9
0.1	-2.4	163.2
-0.2	-1.2	132.3
1.3	7.7	149.5
1.5	8.5	125.5

$$SD = 0.82 + 0.055\ USD - 0.003\ SY \qquad R^2 = 0.22$$

(1.96) Standard error = 0.87

$$SD = 0.54 + 0.055\ USD \qquad R^2 = 0.21$$

(2.02) Standard error = 0.84

APPENDIX B

BRADA AND GRAVES DATA TABLE

Year	Soviet Defense (billion 1970 rubles) High	Low	Real U.S. Defense Expenditures (billion 1980 dollars	Soviet GNP (billion 1970 rubles	Growth of Soviet Factor Productivity (Percent)	Nuclear Warheads USSR	USA
1960	31	23	200.54	232.3	7.03	415	1734
1961	34	26	204.12	245.3	6.07	445	1846
1962	38	29	207.72	254.5	3.90	485	1942
1963	39	31	206.98	251.7	2.97	531	2070
1964	42	34	207.41	279.4	1.40	580	2910
1965	43	35	185.42	296.8	1.87	598	4110
1966	44	36	203.19	311.9	4.10	674	4198
1967	47	39	241.27	326.3	4.90	1058	4338
1968	50	42	260.91	346.0	4.07	1270	4134
1969	52	43	254.62	355.9	2.87	1662	4026
1970	53	44	228.19	383.3	4.43	2047	5074
1971	54	45	203.80	398.2	3.77	3199	6282
1972	56	46	189.41	405.7	2.87	2298	7100
1973	58	48	169.27	435.2	3.87	2430	8164
1974	62	51	156.81	452.2	4.30	2534	8522
1975	65	53	155.59	459.8	6.33	2614	9170
1976	69	56	169.91	481.8	0.63	3219	9518
1977	70	56	170.94	497.4	2.23	4345	9806
1978	72	57	154.12	514.2	1.03	5097	9950

1979	75	59	156.80	516.1	0.17	6336	9945
1980	79	62	160.67	524.7	0.27	7451	9668
1981	83	63	169.55	536.1	0.47	7793	9628
1982	84	64	185.31	547.0	0.07	8031	10124
1983	88	66	201.83	567.5	1.50	8730	10201
1984	90	67	211.35	578.9	1.63	9146	10630

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